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Characterization of tracer responses using fractional derivative-based mathematical model and its application to prediction of mass transport in fractured reservoirs

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Abstract

Tracer testing is a standard method for tracing mass transport within a geothermal reservoir and can be a valuable tool in the design and management of production and injection operations. In this study, we discuss the use of fractional advection-dispersion equation (fADE) model to characterize tracer responses with the objective of predicting mass transport in complex fractured reservoirs. A 3D fracture network model for flow analysis (FRACSIM-3D) is utilized to produce numerical data of tracer responses in fractured reservoirs. It has been shown that the FRACSIM-3D reproduces highly anomalous behavior of mass transport, which is attributable to the preferential pathways that arise because of the degree of fracture connectivity. The fADE mathematical model is applied to analyze the numerical tracer results simulated by FRACSIM-3D. For comparison, the advection-dispersion equation (ADE) is also used to characterize the tracer responses in addition to the fADE. Based on the tracer data obtained for a well interval of 50m, both the fADE and ADE model are applied to predict the tracer responses in the case where the well spacing is extended to 80m. It is demonstrated that the ADE model produces tracer curves which deviate significantly from the FRACSIM-3D results particularly for long-term behaviors, while the tracer responses predicted by the fADE model are in reasonable agreement with the numerically obtained data by FRACSIM-3D.

Keywords

Fractional-derivative, Fractured reservoir, Mathematical model, Reinjection, Tracer test